

lost to the Masai as a watering place. Situated at an altitude of 4,000 feet it is flanked on the east by the Kikuyu Escarpment, and on the north-west by Mount Suswa. Water is not procurable during the dry season, but the area is used by the Masai during the rains when most of the available water then runs to waste. 133

The country between the Kedong Valley and the Uaso Nyiro at Van de Weyer's Drift, is cut up by deep escarpments and studded with ironstone hills, intersected by jagged edged dongas, all of a volcanic nature. The soil is, for the most part, a sandy orange dust. The hill sides are covered with rough thorn bushes and mimosa amongst which a considerable amount of good grass is apparent. The area is practically waterless at most times of the year, but the appearance of watercourses indicates the presence of large holes of surface water during the rains. [34] [37]

Near the Uaso Nyiro lies the country known as Mosiro, level grass country, which affords permanent grazing for large herds of cattle all the year round on account of the proximity of the river and the consequent regular water supply.

To the east lies the country known as L'Odo Kilani, which is the northern extremity of the barren country round Lake Magadi.

The Uaso Nyiro, which is taken as the dividing line between the eastern and central portions of the Masai Reserve for the purposes of geographical description, flows into a swamp to the north of Lake Natron, which contains the lowest part of the reserve, being no more than 2,027 feet above sea level. The valley is fairly healthy in dry weather, but in the rainy season the inhabitants move westwards to the summit of the escarpment, which rises in a series of abrupt and rocky ridges on the right bank of the river from the Anglo-German boundary as far north as the Narosura River. The central portion.

West of this escarpment stand the Loita Hills, rugged masses extending over a wide area of country, watered by frequent streams, and of an altitude generally greater than 7,000 feet. These hills form the watershed of the tributaries of the Mara River, the chief of which in these parts is the Olkeju l'Ongaiant, which follows a course nearly parallel to the boundary and which enters the Mara River as it crosses the border. The Loita Hills present good grazing grounds, well supplied with water and grass, but they are too mountainous and rocky in places to be utilised to their full capacity.

North of the Narosura, and before reaching the Loita Plains, the Narosura Plains present grazing areas of the first quality, whose undulating slopes carry heavy crops of grass and are much frequented by Masai cattle. Permanent water is obtainable at regular intervals from the small tributaries of the Narosura.

The Loita Plains are entered at the Engare Ento and, though there is a deficiency of permanent water in this part, the grazing is otherwise good. The extensive areas comprised in the north-eastern portion of the Loita Plains consists of very open and bleak country, swept by cold winds, which send the temperature at night down to well below 40° F. and carrying a short close grass, which is more suitable for sheep than for cattle. The eastern boundary of the Plains is the Uaso Nyiro, which has not at this time entered into its deep ravine. At Van de Weyer's Drift the river is some twenty yards wide, running with a strong current between fairly high banks and of a depth varying at different seasons of the year, but rarely less than two or three feet deep at the drift. North of Narok Station the heights of the Mau rise through thick bush and forest country, well watered, but practically unusable for stock, to the top of the range and it is through this country that the Uaso Nyiro, with its tributaries, fall until they unite near the drift. 132

West of the Narok lies the main portion of the Loita Plains, a vast area of open grass country, level, or slightly undulating, intersected with small watercourses, which hold water in the deeper cavities and in the neighbourhood of occasional springs at most seasons of the year, and dotted at intervals with copes of bush and scattered clumps of mimosa, a country which possesses magnificent possibilities as a grazing area if a few engineering projects are undertaken to

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THROUGH MASAI LAND.

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between the married and the unmarried people, very little work being expected of the latter, and the sweetheart system being preserved. They all, however, occupy the same village, and of course the young men cannot afford to live on meat, though they always come in for the lion's share when any of it is going. When parties go off on war-raids, they also contrive to eat a bullock by way of getting up their courage.

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They lead upon the whole a very miserable life, ever threatened with destruction by the Masai, who have swept off several villages and all their cattle. The soil being the very richest loam, brought down from the mountains and spread over a comparatively level plain to the south of the lake, it is capable of producing anything; only the extreme dryness of the air and the very small annual rainfall, confined to a couple of months, keeps it sterile and barren. To ameliorate this unhappy condition of things the Wa-kwafi have developed a wonderfully ingenious system of irrigation by artificial canals of (for them) great magnitude. They construct dams across the deep channel of the Guaso Tigrish and thus raise the level of the water to that of the plain, and then, by an intricate network of channels, they spread the precious fluid over a large area, and raise their millet and melons. These products form almost their sole food, eked out by what they are able to kill in the chase and by fish from the river, though when meat is scarce they are not disdainful even of rats. Of these there were simply myriads. They swarmed everywhere, and nothing was too sacred for them. Need it be wondered if "oft in the still night" were heard imprecations loud and deep upon the wretched pests when I have been awakened up by my nose being bitten or the sanctity of my toe invaded. My books were devoured, and even the bullets in my cartridges were not too indigestible. Everything, indeed, had to be kept under iron or hung up under sheds as represented on page 313.

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As in the case of the Wa-taveta, the Wa-njemps are singularly honest and reliable, so much so that valuable goods and equally valuable food are left in their charge with the utmost confidence, and I have heard of no case of this being violated. To me, one of the most remarkable features in the character of the young women and girls was their absolute unconsciousness of fear in my presence, and the complete confidence they seemed to have in me. They indeed took

Of the 15 edible earths analysed (Appendix I, Table V), 13 were definitely richer in sodium than ordinary Kenya soils. The sodium content of these 13 earths ranges from 0.24 to 30.15 per cent. Five of these samples were from the Masai Reserve, and four of them contain high percentages of sodium. The best of these with 30.15 per cent. would form a fair substitute for Magadi soda. In the samples from the Kikuyu Reserve, the highest sodium content is 6.35 per cent.

With regard to the other inorganic constituents, only one of the 13 samples was richer in phosphorus than ordinary Kenya soil. Five of the earths are definitely richer in calcium than soil, ranging from 0.77 to 2.56 per cent. as compared with 0.75 per cent. in soil. Two of these are from an area in the Kikuyu Reserve, and it is interesting to find that they are the most sought after. The source of supply of one of them, viz., Gitirikani earth, which has a calcium content of 1.38 per cent., was at one time in the Masai country. The Kikuyu were then in the habit of making raids and fighting for this salt. They state that their cattle were fatter, bred better, and were more resistant to disease when they had a supply of Gitirikani earth. Similarly in the Masai reserve, the most popular earth is said to be that from Ol Donyorasha, and it has the highest calcium content.

The two edible earths which were not richer in sodium than ordinary soil contained large percentages of iron. These seem particularly popular with pregnant women. On the whole, it is probably true to say that popularity is associated with either a high content in calcium and sodium, or a high iron content.

In addition to plant ash and edible earths, the water from certain springs is held in high esteem, especially by the women, and is used in cooking. Analyses of 15 samples show a fairly high calcium content in some as compared with different waters in Britain (Appendix I, Table VIII), the highest figure being 43.60 parts per 100,000, and the average 9.83.

(iii) *Milk from the Masai Reserve.*

The analyses of 13 samples of milk from different herds of Masai cattle are averaged in the following table and compared with average figures for milk from cows at the Rowett Institute.

				<i>Masai Milk. Home Milk.</i>	
				Per cent.	Per cent.
Total solids	..	..	..	13.77	12.89
Fat	..	..	..	5.48	3.9
Sugar	..	..	..	4.92	4.8
Nitrogen	..	..	..	.57	.54
Total ash	..	..	..	.73	.75
Ca	..	..	..	.129	.119
Na	..	..	..	.037	.056
K	..	..	..	.143	.168
P	..	..	..	.095	.100
Cl	..	..	..	.095	.111
Fe	..	..	..	.00008	.00009

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133 plateau surrounded by peaks. It is 12 to 15 miles across, roughly 2,000 feet deep, and the floor covers about 120 square miles. Willis (1936) considered it a small rift valley, blocked at the ends. James (op.cit.) considers Ngorongoro and the nearby craters of Embagai and Olomoti to be due to cauldron subsidence on a ring fault, with some subsequent in-filling by lake beds. The Highlands are composed of Tertiary volcanic rocks.

In the Rift just north-east of the Ngorongoro Highlands is Mount Lengai, East Africa's only active volcano (Fig. 9). Its conical peak rises to an elevation of 9,443 feet. The volcano occasionally smokes, and periodically it becomes active spewing out large quantities of dust and ashes. Periods of activity may cover several months or longer, the longest continuing from 1913 through 1915 (Guest, 1951). There have been about ten such periods since 1880, or an average of about once each eight years (Guest, op.cit.; Pearsall, 1957). However, since these periods have involved 15 different years, volcanic activity has occurred on an average of one year out of each five and a half during the past 81 years.

The Serengeti Plain is considered to be an
• [134] ancient lake bed. It is largely underlain by rocks of
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• 134 the Basement Complex, ancient metamorphosed and granitized sedimentary rocks with minor igneous intrusions, all of the Archaean age. Basement Complex is derived largely from shales, sandstones and calcareous sediments. Overlaying these rocks are deep deposits of limestones and volcanic ashes, some of which are exposed at Olduvai Gorge (Fig. 10 and 11) where Dr. Leskey has made his famous paleontological discoveries (Cole, 1954; Leskey, 1933).

The surface deposits are calcareous tuff in the east. In the northwestern part of the plains the Basement Complex gives way to granites, which project through in the form of scattered inselbergs or "kopjes." (Fig. 12). Similar kopjes in the eastern plains are of gneiss (Fig. 13).

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133 Much of the northern part of the study area is also underlain by Basement Complex. In the Kenya Mara, a number of separated hills, their summits reaching around 7,000 feet elevation, represent remnants of an end-Cretaceous peneplain. A sub Miocene peneplain underlies parts of the Kenya area, extending discontinuously from the Siria Escarpment eastward through the Loita Hills. This surface is exposed in places, especially on the Siria Escarpment, but farther east it is often

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overlain by Tertiary volcanics.

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• 134 The area near the lower Mara River, leading toward Lake Victoria, is volcanic. Much of the rest of the region south of the Kenya border is granitic, or a mixture of granite, Basement Complex, and quartzites and related rocks of the Ikorongo Series (Bukoba System). Quartzite capped hills and ridges are characteristic of the country from north of the Kenya border south toward the Serengeti Plain, and west to Lake Victoria. These are interspersed with occasional hills capped with Bukoba sandstone or granite, and characteristic granite inselbergs. These similar appearing kopjes are also found occasionally throughout the entire study area.

The area immediately north-west of the Serengeti Plain has a complicated geology. Gold bearing quartz reefs occur in this area, and as a consequence it is particularly well studied geologically (Stockley, 1935; 1936).

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Soils

Methods: We collected soil samples from most sites of vegetation plots, particularly where it was desirable to examine possible correlations between soils and vegetation, fire, and grazing. We dug over

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100 soil pits in the region of the Serengeti Plain, and collected some material from other areas. The method was as follows: We first dug a pit, about one by two feet or larger, and deep enough to get through the top soil horizon. We then took a soil auger and with it dug a hole a minimum of six feet deep, wherever possible. In some areas rock or particularly hard caliche enforced a shallow pit. In a few cases we took advantage of pits or soft earth and dug down ten or more feet deep. The soil from each auger-full was knocked out in turn along a line to form a long pile with the last auger-full at one end and the first at the other. Samples were then collected from each horizon. A description was written, and the location plotted on our map. The samples were sent to the Scott Agricultural Laboratories in Nairobi, who kindly analysed them for us. The following discussion is a brief generalized description of the soils of the study area. Detailed results of the soil analyses will be presented where appropriate later in the text.

General Description:

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/The soils of the Mau and Ngorongoro Highlands are brown or red rich, silty loams derived from volcanic ash. These are underlain by clay or clay loam which is often exposed by erosion. Under forest conditions the humus content of the top soil is high, but erosion is relatively swift when the vegetation is

- (134) cleared by fire, cutting, or grazing.

The eastern Serengeti Plain has a soil derived from, and often largely composed of, calcareous tuff. It is a medium to fine-grained grey-brown tuff which covers the whole of the eastern plains and many of the surrounding hill tops. The Salai Plain and adjacent parts of the Serengeti Plain are covered by dunes of black volcanic ash. The ash comes from the periodic volcanic activity of Lengai volcano which is immediately (132) to the southeast. Southeast winds prevail most of the year, and although the dunes are mostly stabilized by vegetation (Fig. 14), the influence of the winds can be clearly seen in their form and orientation. At several points in the eastern Serengeti there are small shifting dunes, famous in East Africa as the "Shifting Sands." These are actually small unstabilized barchans formed of the same black ash. In periods of volcanic activity considerable quantities of this ash are deposited over the plains. Residents of Tanganyika told us of travelling through the central plains immediately after an eruption and of finding ash covering everything in deposits up to two feet thick at distances of over (134) 40 miles from the volcano. These eastern soils are immature, often undifferentiated to a considerable depth. The texture is very loose. Except where

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- 134 stabilized by a good vegetation cover, the soil surface and the organic matter are frequently in motion, being blown westward. These soils are quite rich in soluble minerals but very low in nitrogen, especially where vegetation cover is lacking. They often have a shallow underlying hardpan (Fig. 15).

In the west of the Serengeti Plain the loose ash grades into gray and black sedimentary soils. In the lower, less well drained areas these soils are heavy calcareous black or gray clays, the "Black Cotton" clay of East Africa. Underlying these surface loams or clays is often a red clay, and to the north and west of the Serengeti Plain, except in the valley bottoms, the predominant surface soils are red earths. Heavy black loam or clays are found in the valley bottoms, especially in the valleys of the Grumeti and Mbalangeti Rivers. There is a clearly defined catena structure on the slopes of the western hills, extending from the exposed rocks on the ridge tops through the red earth slopes to the dark sedimentary soils in the bottoms.

North to the Kenya border the red earths predominate, with black heavy sediments in the bottoms and catena structures similar to those of the western

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- 134 area. The valley of the Mara river in Tanganyika has soils derived from volcanic material. In the Kenya Mara the progression of soil types from west to east is similar to that in the Serengeti. In the Mara Plains the bottoms are typically heavy gray or black loam or clay. This grades to red soils on the surrounding hills, and to a light, calcareous soil derived from volcanic ash on the Loita Plain in the east.

Climate

- #114 Because of the isolation of the area and the
#126 low human population, climatic data from Western Masai-
*132 land are very sketchy. However, there are some data from records of the East African Meteorological Department at Nairobi, the District Administration at Narok, and the Serengeti National Park. The following discussion is based on these records and our own observations.

- *132 Western Masailand lies within the Tropical Savanna (Aw) Climate. Local factors influencing the weather in this area include the mountain masses bordering the area to the north and south, Lake Victoria to the west, and the arid Rift to the east (Fig. 3).

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Figure 16.

Isolated rain storms in Ngorongoro Crater. This rainfall is typical of the dry season precipitation in Western Masailand. The shower on the left is mostly evaporated before it reaches the ground. The storm on the right is torrential causing heavy run-off. Both are very localized and the ground around them remains dry. The light colored deposits are alkali from the dry lake bed in Ngorongoro.

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Outside of the peak rainfall, most precipitation comes in the form of torrential storms or brief, light showers. The maximum amount of rain recorded in any 24 hour period in the study area is only 3.5 inches, but many storms only last a few minutes. The rainfall may be so heavy in these scattered storms that where they pass over areas without a high vegetation cover, the splash creates a ground-obscuring mist two to three feet high. We measured up to 0.45 inches of precipitation from such storms, which often lasted less than a half hour.

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There is very heavy run-off following such storms and unless there is a good vegetation cover the combination of the splash impact and the run-off causes considerable erosion.

The light showers frequently do not even reach the ground, and when they do they often have relatively little effect. The ground surface is hot and a desiccating wind usually blows day and night. Much of the precipitation that reaches the ground from light showers is evaporated almost before the cloud passes on.

During the peak of the rains the daily precipitation is somewhat higher than the yearly average (Table 4).

Due to the more general overcast there is less evaporation

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¹²² below the general overcast. We watched it at a range of about 10 miles for about 15 minutes, before it passed out of sight. Small "dust devils" were common on any hot, windy day, but this was the only large scale cyclonic column of this sort that we saw. Roosevelt (1910) referred to seeing "a waterspout or cyclone" one stormy evening near Mt. Kenys. This is the only other reference we have found to this phenomena.

SUMMARY: Western Masailand lies within the Tropical Savanna (Aw) Climate, and local weather influences include the Lake Victoria on the west, mountain masses in the north and south, and the arid Rift Valley on the east. Average annual rainfall follows a gradient from about 40 inches near Lake Victoria to about 20 near the Rift. Some rain may fall in any month, but the most rainy period is November through May, with peaks in March and April. Rainfall is very irregular in occurrence and distribution; two years out of three expect below average rainfall, and one year out of four expects less than 20 inches. Most rain falls in the form of short torrential storms or showers, hence much of the rainfall may be lost to the vegetation and underground water supplies through immediate erosive run-off or evaporation. Potential evaporation appears to exceed

*137 Trampling

Trampling can be a factor in killing some perennial bunch grasses, while annuals and perennials such as Pennisetum are quite resistant to it.

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Where domestic livestock are herded back and forth along the same routes the hooves cut through the turf and cause some erosion (Fig. 68). In areas of loose soil, especially in the eastern plains of the study area, this factor is quite serious.

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Wild animals also create trails. During the seasonal migrations long lines of zebras and wildebeests follow one another nose to tail and the resultant trails are quite conspicuous (Fig. 73). Since these trails normally are only used once each season the erosion effect is minimized. Where migratory movements are compressed into saddles between hills or narrow valleys these trails are worn very deep and have become a characteristic physical feature of the country.

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Domestic livestock are closely herded in tight bunches (Fig. 24 and 25) which accentuates trampling damage. The wild animals graze in open formation. Even large herds of wildebeests are relatively openly spaced (Fig. 74) which reduces trampling damage, even from very large numbers of animals.

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* [136] by tsetse fly -- so must have been relatively open.

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* [233] 1850-1890: This appears to have been a period of increased burning, expansion of the Masai into the lands north of the Serengeti up to the Mara Plains, and increasing numbers of livestock. The open grasslands reached their greatest extent during this period, and the area between the Serengeti Plain and the Mara became open grassland with riverine forest and scattered thickets, much like the present southern Mara Plains (Fig. 79a).

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[101] The Masai apparently extended their grazing and particularly burning far up into the Mau Escarpment. Spectacular erosion can be seen over much of the Mau Escarpment north and east of the Loita Plain. Virtually no top soil can be seen over hundreds of square miles at the lower elevations, and where some does remain it may be 10 to 14 feet above the present ground level, on top of a pedestal of earth held against erosion by the roots of a few surviving cedar trees. Trees growing in the bottom of these erosion scars in 1960 were dated as being 50 to 80 years old which would put the period of recovery in the late 1800's at or after the disasters of the Masai. During the period of dry years culminating in 1961 the Masai extended their

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(101) burning and grazing far up into the same area of the forest, and the torrential rains that followed the dry period in 1961 created new erosion scars of as great magnitude as those of the earlier period.

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[73/] At the peak of the power of the Masai in the 1880's they had very large numbers of livestock. Their peak of intensity of livestock grazing, and probably overgrazing, came at the onset of the droughts which culminated in the famine of 1890. Conditions may have been much the same as in 1961. The effect of grazing animals on the vegetation, as well as the impact of fires where there was fuel, probably reached a peak about 1890. It is probable that a brush invasion through overgrazing was already starting in some of the open grassland.

[101] 1890-1918: The result of the combination of disasters that struck the Masai in the 1890's was that they largely vacated the Serengeti Plain and the country to the north all the way to the Lolita Plain. There was a period of about 15 years of very much reduced grazing by domestic livestock and apparently reduced grass burning, and for part of this period there was probably almost no regular grazing or burning. This was